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SUPPLY OF THE CEREBRUM

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THE MECHANICAL FACTOR IN COMPENSATION OF ARTERIAL BLOOD
SUPPLY OF THE CEREBRUM

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Scientific Research Institute of the Decoration of the Labor of Red Banner of Neurosurgery named after Academician N. N. Burdenko of the Academy of Medical Sciences of the U.S.S.R.

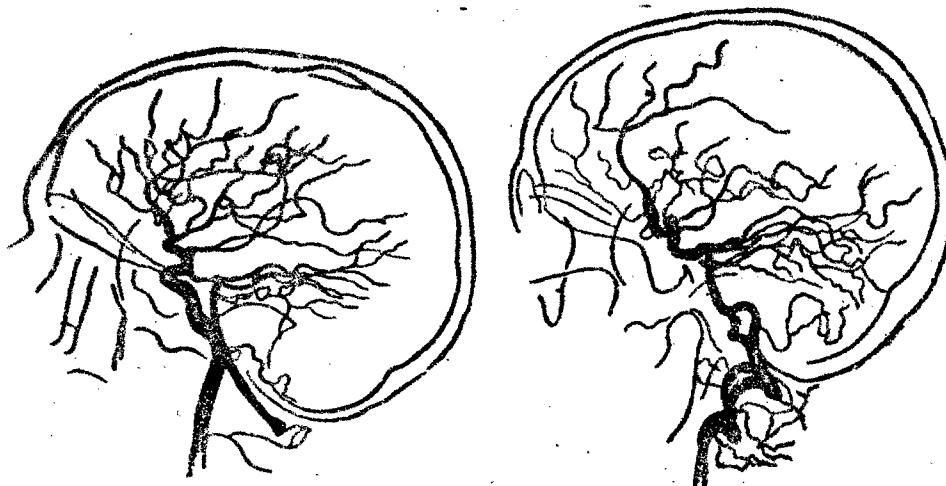


Fig. 1. Filling through the posterior communicating branch of the posterior cerebral, basilar and vertebral arteries with their branches during angiography employing the interior carotid artery.

Fig. 2. Filling of the arteries of the interior carotid sinus, anterior and middle arteries during angiography through the vertebral artery during a simultaneous filling of the vertebral artery on the opposite side.

The observation of Monits and other authors including our own have shown that the injection of contrast medium into the system of the interior carotid artery causes, in 20 - 25% of cases the filling of the posterior cerebral artery. The authors consider this peculiarity as a variant of the branching of the posterior cerebral artery from the interior carotid artery, and in fact such anatomical variation exists. However, more often the filling of the posterior cerebral artery during angiography takes place not directly from the interior carotid artery but through the posterior communicating artery (through a more narrow vessel than the posterior cerebral artery itself). We have observed during angiography utilizing the carotid artery a filling not only of the posterior cerebral artery but also of the basilar and even of the vertebral arteries (Figure 1). During vertebral angiography it is possible to have reverse filling of the vessels of the posterior carotid area through the arteries of Willis's circle, i. e., middle and anterior cerebral arteries (Figure 2).

We note that during the injection of contrast medium into the posterior carotid artery of one side often both anterior cerebral arteries are filled (through the anterior communicating arteries) and sometimes the middle cerebral artery on the other side is demonstrable (Figure 3).

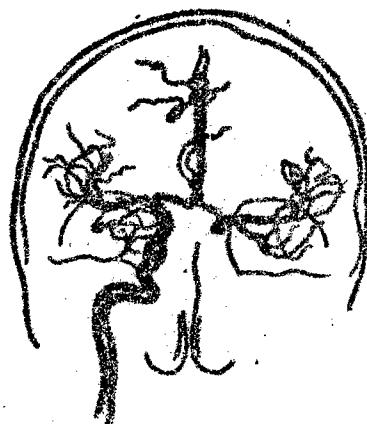


Fig. 3. Filling of the hemispheric artery during compression of the carotid artery and the injection of contrast medium into the interior carotid artery of the opposite side.

Several authors employ compression of the carotid artery on the lesion side for contrasting this side when the opaque medium is injected into the system of the interior carotid artery on the opposite side. Such a

necessity arises from trauma and lesions of the vascular magistrals of the neck, which makes it more difficult to directly inject the contrast medium into the vessels of the side to be investigated.

When we summarize our own experience and that of other authors, we can note that sometimes during the angiography of cerebral vessels the filling of one side through the vessels of the other side occurs in spite of the circulatory direction. Therefore blood and contrast medium pass through the arteries supplying the anterior sections of the brain to the posterior sections and visa versa; this passage occurs between the arterial systems supplying the anterior and posterior sections of the brain.

Aside from such free communication in the cerebral artery system (both the interior carotid arteries and the basilar artery), we have observed cases of "spreading" of opaque medium into the arterials in the area of the exterior carotid arteries. Thus, during the injection of contrast medium, we have seen the filling of the posterior meningeal artery through the middle meningeal or from the system of the exterior carotid artery into the system of the interior carotid artery (through the ophthalmic artery or the communications between the arteries of the dura mater and pia mater).

This data becomes understandable if we take into account the absence of valves in the arteries of the brain and skull, however we wish to emphasize that all this data which appears paradoxical is not irregular in occurrence. We stress the physiological compensative significance of the presence of free communications for the arteries of the symmetrical hemispheres of the brain as well as the non-symmetrical - anterior and posterior. When the skull and brain are in various positions or under conditions where there is a restriction of blood flow on one side or group of arteries, e. g., during compression of the cervical and occipital vessels while sleeping in a horizontal position (or in other body positions), the vessels of the other side compensate for any insufficiency of the brain and skull blood supply. In thrombosis, emboli and other vascular pathologic entities may destroy the circulation of a vessel and then neighboring vessels of the same or the other hemisphere compensate for the insufficient blood supply in their zone.

In the hemodynamics of the circulatory arterial phase of the two cerebral hemispheres there is a pressure zone of "labile equilibrium". Blood passes freely through this

zone depending upon the physiological requirements of the brain and skull.

During brain angiography the opaque filling of the large arterial vessels from the region of the same of the opposite side is always called to our attention because it shows the breakdown of the pressure equilibrium in the regions of these arteries. The lowering of pressure and therefore the lessening of circulation in the arterial system, if it is not an artifact, may point to a mechanical or functional stenosis of the lumen of the afferent portion of the respective contrast-medium filled artery.

In the light of the data that has been considered, it becomes understandable that this is not a negligible situation for the surgeon, i. e., in brain angiography we do not always see the filling of the rather large communicating vessels which connect regions of both hemispheres, which are especially numerous near the base of the skull in the middle cerebral sections-circulus arteriosus villosii and other anastomosing vessels. Furthermore, it is understandable that the noted anastomosing channels are in the zone of "labile equilibrium", and that they are filled with blood or contrast medium only when there is a functional requirement and that there are invoked corresponding mechanical hydrodynamic conditions, i. e., a difference in pressure occurs at the end of an anastomosing vessel. In this connection the circulation in anastomosing cerebral arteries may be directed to both sides depending on the mechanics of pressure differences, and if there is a necessity for filling such communicating vessels such a difference should be set up by compressing the large artery on the side opposite to the side where opaque medium is injected.

We are far from able to minimize the importance of neurogenic influences in this perplexing physiological phenomenon while paying proper attention to the mechanical and hydrodynamic factors of the cerebral circulation. It is quite understandable that this perplexing cerebral circulatory process cannot be explained on the basis of simple hydrodynamic moments. The size of the lumen of such vessels as well as the speed of blood circulation is bound with the tonus and condition of the vascular walls. At the present level of understanding in science one cannot imagine such a condition without influence from the central nervous system. Also, the influence of blood chemistry on receptive stimuli and neurogenic mechanism is well known.

Conclusions.

1. The blood supply of the symmetrical hemisphere of the brain is assured by paired arteries connected in the middle zone by the communicating arteries of Willis' circle.
2. The communicating arteries in the median plane as well as those over the periphery of the hemispheres represent a zone of "labile equilibrium".
3. The communicating arteries bind, through the zone of "labile equilibrium," the symmetrical cerebral areas as well as the asymmetrical ones - the anterior sectors of the hemispheres to the posterior areas and visa versa.
4. The circulation in the zone of "labile equilibrium" flows in either direction depending on blood pressure differences set up in the hemispheric arteries or in the different zones of one hemisphere. In the zone of "labile equilibrium", the circulatory direction of the communicating arteries varies and is always towards the side of lower pressure.
5. The coordination and direction of the circulation between the brain hemispheres and also between the anterior and posterior halves of each hemisphere are determined by mechanical hydrodynamic factors concerned with the fluid pressure differences in the interconnected vascular systems.
6. The influence of central nervous system regulation determines the conditions of the vascular walls and through this the blood volume as well as the speed of circulation are corrected.
7. The phenomenon of arterial blood "spreading" from the region of one cerebral artery into that of another has great physiological significance (the conductance of contrast medium in angiography, etc.).
8. A necessity for such compensation occurs normally during circular changes in the vessels of the neck and head dependent upon posture and in relation to any compression of such vessels in wakefulness or while sleeping. Such conditions may be induced artificially by applying pressure to either the carotid or vertebral arteries. In pathological states such compensations, in conjunction with the zone of "labile equilibrium" are necessitated by any circulatory disturbance on either section of the cerebral arterial system, e. g., thromboses, emboli, aneurism ruptures, spasms, etc.
9. The phenomenon of the "spreading" of blood in

the system of conjugated arteries during pathological changes in the brain requires analysis with disregard for topical presentations on the distortion locus of the normal circulation of the cerebral vascular system.

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